Experimental study of the effect of composition on water solubility in natural silicate melts

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Water is the first dominant volatile dissolved in magmas. Oversaturation and exsolution of the water in magmas affects the buoyancy and excess vapor pressure of the system, and hence the water solubility in silicate melts is fundamental in controlling magma transport beneath volcanoes. Many experimental studies of the solubility for water in natural silicate melts are now available, but most of them were performed over a limited range of composition. For example, published solubility data for water are rather sparse for the natural silicate melts having moderate SiO_2 contents. This has resulted in insufficient data coverage of composition space, which makes difficult to precisely model if a melt is subject of compositional change due to partial crystallization, assimilation, or magma hybridization. This study presents results from experimental determinations of the solubility for water in a natural dacitic melt at near-the liquidus and the superheated conditions.

The starting material for the experiments was the natural subalkaline dacite JA1 (GSJ standard reference material, ~65 wt% SiO_2). A nominally anhydrous glass was prepared from the starting material, and the glass was equilibrated with water in an internally heated pressure vessel for ~24 hours at 1000-1200 °C and 100-200 MPa. Double capsule technique was employed to control the oxygen fugacity in the sample along Ni-NiO buffer during the experiments. The water content in the quenched glass was determined from the near infrared absorption intensities of the hydroxyl groups band at ~4500 cm^{-1} and the molecular water band at ~5200 cm^{-1} using the molar absorption coefficients of Ohlhost et al. (2001).

Results of this study are overall consistent with previous determinations of pressure- and temperature-dependence of water solubility in rhyolitic melts. Water solubility in the dacitic melt increases with pressure at a fixed temperature, and decreases with temperature at a fixed pressure. On the other hand, the water solubility in the dacitic melt was found to be 10-20 % (relative, on the mole fraction basis) greater than those previously determined by Holtz et al. (1992; 1995) and Yamashita (1999) for the rhyolitic melts when compared at the same pressure and temperature condition. This advocates that the effect of melt composition play a noticeable role in controlling the degree of water oversaturation during magmatic processes. When a hotter basaltic magma is injected to a colder rhyolitic magma body, a purely thermal effect on water solubility enhances formation of vapor bubbles in the rhyolitic magma (e.g., Yamashita, 1999). Once hybridization between the melt portions of the two magmas proceeds, the effect of melt composition on water solubility becomes important, i.e., already present, sub-millimeter size bubbles (thus their buoyant separation is limited) can be resorbed by the hybridized melt which has an intermediate composition.

References: Holtz et al., Chem. Geol., 96, 289-302, 1992; Holtz et al., Amer. Mineral., 80, 94-108, 1995; Ohlhost et al., Chem. Geol., 174, 5-20, 2001; Yamashita, J. Petrol., 40, 1497-1507, 1999.

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